ROAD SURFACE TREATMENTS ASSOCIATION

Guidance Note on Quieter Surface Dressings

Preface

This Guidance Note is based on research commissioned at The University of Ulster with financial support from the Highways Agency.

The research was carried out under the supervision of Professor Alan Woodside and Dr David Woodward wrote this note with guidance from a panel consisting of:

Richard Ellis	Ringway Specialist Surface Treatments Ltd
Peter Kinsey	Highways Agency
John Simpson	Road Maintenance Services Ltd
Stewart Struthers	Colas Ltd (Chairman)
Ian Walsh	CSS (Babtie Group Ltd)
John Williams	Highways Agency

Steve Brown and Chris Summers kindly assisted by providing information on and access to sites in Leicestershire.

EXECUTIVE SUMMARY

1. This Guidance Note is intended to give Highways Engineers advice on the background and current state of knowledge to assist with a better understanding of tyre / road noise and the complex mechanisms involved. The relationship between high positive texture and road noise is highlighted.

2. Based on the current state of knowledge advice is given on selecting the type of surface dressing to minimise tyre / road noise. In most cases it will be possible to select a dressing, which will be comparable to SMA type thin surfacing. However it is important to emphasis that in selecting the type of dressing to use various factors must be taken into consideration. The engineer should not forget that one of the main reasons for surface dressing is to restore skid resistance and any dressing installed which does not maintain texture may not be cost effective.

3. Road Note 39 5th edition should continue to be used as the design guide and Section 6 gives advice on how to use the Road Note to design quieter surface dressings following the assessment of surface texture / noise given in figure 5. This advice can be summarised as:-

    - Use the smallest size chipping permitted for the applicable traffic category and road hardness in accordance with Table 9.2.3a not Figure 8.2.1.1 & Figure 8.2.2.1
    - Where traffic and road conditions require a more robust dressing use a double dressing rather than a racked – in dressing

4. Traffic speed is a significant factor in the generation of tyre / road noise. Engineering a reduction in mean speed maybe a more cost effective means of reducing traffic noise than installing a more expensive surface and will assist further in reducing traffic accidents.

5. The only surface dressings with a positive USI have a primary chipping size of 14mm. However, the Road Note does not generally recommend the use of 14mm and furthermore, 10mm dressings have a negative USI that is better than 10mm bitumen macadam (See figure 4).

1. INTRODUCTION

1.1 Surface dressing is a cost effective and widely used highway maintenance tool. It extends the life of a pavement by sealing its surface to prevent the ingress of moisture whilst restoring texture and skid resistance. However, the introduction of thin surfacings that are relatively quiet and the increasing public awareness of traffic noise have exacerbated the perception that surface dressing generates unacceptable levels of noise. This need not be so. The aim of this Guidance Note is to show that surface dressings can provide an economic and acceptable surfacing option in an appropriate context.

2. BACKGROUND

2.1 Noise is defined as unwanted sound and is a subjective term open to many different opinions, particularly those who live and work close to a noisy road. Tyre/road noise forms part of the total noise emanating from a moving vehicle. It is produced by the interaction of vehicle tyres and the road surface and now constitutes a major concern for those involved in the design, manufacture and specification of highway surfacing materials.

2.2 The origins of tyre/road noise coincide with the historical need to provide safer roads. With the introduction of motorised vehicles and increased speeds it became apparent that smooth road surfaces became dangerous particularly when wet. Escalating numbers of road deaths necessitated a rougher surface to provide a level of grip to ensure an increased minimum safety. Spraying the road surface with binder and applying a layer of chippings quickly became the recognised method of achieving better grip. Careful selection of aggregate that resisted polishing provided a rough, positive textured surface that was safe both at low speeds and more importantly was able to provide rapid removal of water a higher speeds.

2.3 This need for texture has subsequently effected the development of bituminous surfacing mixtures in the UK throughout the 20th century. The predominant hot mix materials were hot rolled asphalt for heavily trafficked roads and bituminous macadam for roads carrying lighter traffic. The use of hot rolled asphalt for high-speed roads was replaced in the 1990's by proprietary surfacing materials. These typically use higher stone content mixes with smaller chipping sizes, resulting in surface textures that generate less tyre noise.

2.4 A noise test became part of HAPAS (Highway Authorities Products Approval Scheme). For comparison purposes, a standard road surface was considered to be as implied by the Calculation of Road Traffic Noise, that is equivalent to a hot rolled asphalt with 2mm of texture depth. The Highways Agency implicitly defines a quieter surface as one that generates 2.5dB less noise than the standard surface under the specified test conditions (by comparing performance against that of HRA with 2.00mm texture).

2.5 These proprietary materials achieve skidding resistance by providing greater aggregate contact area to the tyre in comparison with chipped surfaces. Water removal is achieved through the open (negative) texture. The more uniform pressure distribution means that there is not the same degree of aggregate interaction into the tyre tread and consequently the negatively textured surfacing materials are quieter than conventional single sized dressings.

2.6 With increasing public experience of these proprietary surfacings, traditional types of surfacing are now regarded as being excessively noisy. This perception applies to all positively textured surfaces, not just surface dressing. It must be remembered that the commonest experience of different road surfaces is as a driver or passenger and the noise received is modified by the suspension system and other mechanisms such as internal damping.

2.7 Although the public now expect a road surface to be quieter, there are other properties that must be considered by a highway authority when selecting the most appropriate type of surfacing. The UK government and many Local Authorities now recognise the importance of reducing noise. But for authorities working with limited budgets, surface dressing remains the most cost-effective means of surface treatment in many locations. A summary of the current perception of relative comparisons between surfacing options is set out in Table 1.

2.8 The aim of this Guidance Note is to show that surface dressings can provide a viable surfacing option that is more cost-effective than alternatives without generating an unacceptable level of noise.

3. THE MECHANISMS OF TYRE/ROAD NOISE GENERATION

3.1 The complex mechanisms of tyre/road noise generation are characterised by a series of classical descriptions. There are two main sources of noise i.e. mechanical vibration of the tyre and aero-dynamical phenomena. The basic phenomena are illustrated in Figure 1.

3.2 There has been a considerable body of research regarding the factors that influence tyre/road noise and a number of standard methods of measuring it have been developed. Further information can be obtained from the selected reading list.

3.3 The generation of tyre/road noise is affected by many other factors, ranging from how the vehicle is driven to the age and temperature of the surface. The following inferences have been taken from the referred reading:

- Speed – tyre/road noise dominates during almost all types of driving for cars and above about 40km/h for trucks.
- Speed influence – as a general rule tyre noise increases in proportion to the logarithm of speed, but the relationship between speed and noise for certain tyre/surface combinations appears to deviate from this simplification.
- Different road surfaces – the type of road surface is the predominant factor affecting tyre noise (for a given speed of traffic) in the UK. Positively textured surfaces tend to be more reactive to the type of tyre and tread pattern than those with negative texture.
- Tyre type – tyre/road noise number may vary by more than 5 dB across the range of different tyre types on the same surface at the same speed. The relative performance of different tyres depends on the surface and speed conditions.
- Tyre tread – “knobbly” tyres are not always the noisiest type of tyre. It depends on how they interact with surface texture.
- Tyre width – in general wider tyres generate more noise (about 0.3 dB per cm difference for the same type of tyre).
- Quieter roads and safety – there need be no trade-off between lower noise emissions and skidding performance.

- All road surfaces are noisier when wet; although porous surfaces are considerably quieter than surface dressing when dry, the residue of water retained in the pores diminishes their advantage over impervious surfaces which dry out a lot quicker.
- Age of road – tyre/road noise levels will change as the surfacing changes with time. Loss of texture tends to reduce noise; loss of porosity or chippings tends to increase noise.

4. IN SITU MEASUREMENT OF TYRE/ROAD NOISE

4.1 Traffic noise from a section of road depends on the flow and classes of passing vehicles. Each vehicle generates noise from the engine, transmission and exhaust as well as at the tyre/road interface. Engine/transmission/exhaust noise is related to factors such as engine speed, engine load, vehicle speed, acceleration, and gradient. Tyre/road noise is related to vehicle speed and road surface characteristics such as texture and porosity.

4.2 It has become increasingly important to be able assess the acoustic properties of different types of road surface, particularly in the definition and certification of low noise road surfaces. It is important to eliminate or standardise the influence of traffic and vehicle related factors to classify the contribution of tyre/road noise associated with a particular surface.

4.3 The HAPAS noise test is based on the ISO Statistical Pass-By method (SPB) as implemented by BS EN ISO 11819-1: 2001. It is used by road and environment authorities as a standard tool for comparing traffic noise on different road surfaces for certain specified compositions of road traffic for the purpose of evaluating different road surface types. Vehicle noise levels are measured at the side of the road and is applicable to traffic travelling at constant speed i.e. free flowing at speeds of 50km/h and greater.

4.4 Where traffic is not free flowing the road surface is of less importance than that generated by the vehicle. The surface must have been trafficked for at least 12 months before testing with the texture depth in the nearside wheel-path being to within 10% of the overall section. The data recorded are combined into a single ranking of noise emission for given traffic conditions and compared with the noise level predicted for a standard surface assumed in the calculation method CRTN88, equivalent to HRA with sand patch texture depth of 2mm.

4.5 The Road Surface Influence (RSI) is defined as the difference between the calculated traffic noise level and the theoretical level for the reference surface with the same traffic conditions. The SPB method has certain limitations that affect its use. Measurements need to be taken at an open site with no large reflecting objects on a flat, straight section of road. Therefore, the results apply to a short section of road surface, usually in the nearside lane.

4.6 The Close-Proximity method (CPX) was developed by the International Standards Group as an alternative method of characterising road surface noise and is defined in ISO/CD 11819-2: 1997. It is based on continuous noise measurements from microphones located close to a test tyre mounted on a specially adapted vehicle or trailer. This method allows measurements to be taken at arbitrary locations and continuously along sections of road. The CPX method is suitable for conformity of production testing and routine assessments of the acoustic performance of road surfaces.

4.7 The Transport Research Laboratory TRITON machine is the only example of CPX equipment currently available in the UK. Based on a DAF truck, the TRITON machine can make measurements up to and including the UK speed limit of 70mph using four different test tyres specified in ISO/CD 11819-2 to calculate a Close-Proximity Index (CPXI). The CPX method is more flexible than the SPB method and can be used assess long sections of road relatively quickly.

4.8 However, the results obtained are not directly comparable with roadside (SPB) measurements. The latter are influenced by the way that noise propagates across the surface and the lack of correlation is particularly marked in the case of porous surfaces. Unlike most trailer based CPX machines, TRITON measures noise from a tyre running in the wheel track, but is generally confined to operate in the nearside lane when running in traffic.

5. LABORATORY MEASUREMENT OF EXPECTED TYRE/ROAD NOISE FROM DIFFERENT TYPES OF SURFACING MATERIAL

5.1 As part of the preparation of this Guidance Note, an attempt was made to obtain typical values of expected road noise from different types of surface dressing, either by measurement onsite or from case studies reported in relevant literature. It was found that there was little or no data available on surface dressings.

5.2 It was concluded that a laboratory study was the most effective way of obtaining results under controlled conditions. This used the ULTRA apparatus at the University of Ulster to rank different types of surface in terms of noise generation.

5.3 The method developed is similar to the CPX method where a continuous surface of test specimens is assessed for noise. Development of this method is reported in a supplementary report prepared for the RSDA and gives details of the methodology and main findings.

5.4 The test surfaces assessed were from actual road locations around the UK. Table 3 gives details for each surface. They included 4 differing types of surface dressing selected to give a range of texture depth.

5.5 One of the main aims of the investigation was to minimise the variables encountered with the on-site measurement of noise. A method was developed to make latex copies from each test surface. These were then used to make curved replicate castes using a two-part resin mixture. Use of a hard resin removes the effect of variables associated with rock type, aggregate wear and other changes in test surface texture during testing.

5.6 Fifteen identical curved test specimens were mounted on the internal drum surface of the ULTRA machine. Each set of test surfaces was conditioned for two hours prior to testing. Noise measurements were taken at a range of speeds up to a maximum of 100kph. Both a smooth and treaded tyre was used with tyre pressure and amount of loading varied.

5.7 The microphone was positioned at an angle of 45^0 to the rolling direction, 100mm above the contact area and 200mm from the un-deflected sidewall of the tyre. One-third octave band sound pressure levels were obtained for 1 minute duration for each tyre / pressure / speed / loading combinations across 12 to 20kHz. An example of the noise data obtained is shown in Figure 2.

5.8 An ULTRA Surface Influence (USI) value was calculated for each surface and testing combination. This is defined as the difference between the measured noise level for a given surface and the measured level for the reference surface i.e. HRA with 2mm of texture depth as measured using sand patch.

USI = Test Surface – Reference Surface

A negative USI indicates a Test Surface that is quieter than the HRA Reference Surface.

A positive USI indicates a Test Surface that is noisier than the HRA Reference Surface.

5.9 A summary of USI results for a range of surface types, measured at 50 and 100kph, under standard conditions are shown in Tables 4 and 5 and plotted in Figures 3 and 4 for smooth and treaded tyres respectively. The data show the effect of speed, tyre tread and surface type.

5.10 For a smooth tyre, all the test surfaces are less noisy than the HRA Reference Surface. The one exception is 14/6 surface dressing which is slightly noisier at 50kph. The remaining test surfaces display a range of values depending on stone size, texture depth and surface roughness.

5.11 The data for the treaded tyre show the problems associated with predicting noise from one set of conditions to another. For example, the smooth resin surface at 100kph was the noisiest test surface. This is probably due to the 6mm deep tread being strongly affected by stick-slip. The 6mm single surface dressing at 50kph was quietest along with 14mm SMA. Again, the 14/6mm racked in surface dressing was the noisiest road surface at the lower speed.

5.12 The ranking of USI for the surface dressing test surfaces was correlated with stone size and texture depth i.e. smaller stone sizes and lower texture depths reduce tyre / road noise. The general relationship for surface dressings is shown on Figure 5.

6. RECOMMENDATIONS TO REDUCE NOISE ASSOCIATED WITH SURFACE DRESSING

6.1 The foregoing Sections demonstrate the complex link between aggregate size, texture depth and road / tyre noise. The results summarised in table 4 confirm that it is only the surface dressing with 14 mm nominal size aggregate that generates road / tyre noise greater than the HRA reference level and that a 6 mm nominal size single dressing will have a negative USI similar to 14 mm SMA.

6.2 The 5th edition of Road Note 39 published in November 2002 does not generally recommend the use of 14 mm aggregate except where the weight of traffic and road hardness make the maintenance of texture depth considerations paramount. In these circumstances the dressing when first installed will generate road / tyre noise greater than the reference level. However most surface dressing designed in accordance with the Road Note will use a 10 mm aggregate as the primary chip and will have a negative USI significantly better than the reference level.

6.3 Where minimising road tyre noise is imperative the selection of aggregate for the primary chip should be based on table 9.2.3a on page 33 of the Road Note 39 using Fig 5 of this Guidance Note as guidance. On sites where conditions demand a more robust dressing a racked – in dressing should be avoided and a double dressing used instead. This is because the second layer of smaller chippings in the racked – in dressing has less contact with the vehicle tyre and the influence of the smaller chip on road / tyre noise may be less. On the other hand the smaller chipping in the second layer of a double dressing is likely to have tyre contact similar to a single dressing of the same size and have similar road / tyre noise characteristics.

6.4 In selecting the surface dressing design the Designer / Engineer should bear in mind that a primary reason for surface dressing is to restore texture depth and that it may be more cost effective to install a dressing which is somewhat noisy in early life but will maintain texture for longer. As pointed out in Section 3 tyre / road noise levels change over time and surface dressing will become less noisy over time where other types of surfacing tend to become more noisy.

7. SUGGESTED FURTHER READING

British Standard Institute 2001 BS EN ISO 11819-1:2001. Acoustics – Measurement of the influence of road surfaces on traffic noise – Part 1: The Statistical Pass-By Method. ISBN 0 580 35355 0.

International Organisation for Standardisation ISO 11819-1:1997. Acoustics – Method for measuring the influence of road surfaces on traffic noise – Part 1: The Statistical Pass-by method, Geneva.

International Organisation for Standardisation ISO /CD 11819-2:1997. Acoustics – Method for measuring the influence of road surfaces on traffic noise – Part 2: The Close-proximity method, Geneva.

Kuijpers AHWM 2001. Further analysis of the Sperenberg Data. Towards a better understanding of the processes influencing tyre/road noise. Report No. M+P.MVM.93.3.1 prepared for Dutch ministry of Public Housing, Physical Panning and Environment, The Hague, Netherlands.

Kuijpers AHWM 2001. Tyre/road noise modelling; the road from a tyres point of view. Report No. P.MVW.01.8.1 prepared for Ministry of Transport, Public Works and Water Management, Delft, Netherlands.

Phillips SM and P Kinsey 2000 Advances in identifying road surface characteristics associated with noise and skidding resistance. PIARC SURF 2000, Nantes, France.

Phillips SM and P Kinsey 2001 Aspects of vehicle and traffic noise control. UBA Workshop – Further noise reduction for motorised road vehicles, Berlin.

Phillips SM and PG Abbott 2001 Factors affecting statistical pass-by methods. Proceedings of Internoise 2001. The Hague, Netherlands.

Phillips SM, Kollamthodi S and PA Morgan 2001 Classification of low noise road surfacings. Proceedings of Internoise 2001, The Hague, Netherlands.

Phillips SM, Kollamthodi S, Nelson PM and PG Abbott. 2004. Study of medium and high speed tyre/road noise. TRL Project Report PR SE/849/03.

Sandberg U 1999 Low noise road surfaces – a state of the art review. Journal of the Acoustical Socirty of Japan, Vol 20, No. 1.

Sandberg U 2001 Tyre/road noise – myths and realities. Proceedings of Internoise 2001. The Hague, Netherlands.

Sandberg U 2001. Noise emissions of road vehicles – effect of regulations. Final report by the I-INCE Working Party.

Sandberg U and J Ejsmont 2000 Noise emission, friction and rolling resistance of car tires, Summary of an experimental study. Proceedings of NOISE-CON 2000, California.

Sandberg U and J Ejsmont 2002 Tyre/road noise – Reference Book. INFORMEX, Harg, SE-59040, Kisa, Sweden ISBN 91-631-2610-9.

8. DEFINITIONS TAKEN FROM BS EN ISO 11819-2001

Absorptive noise barriers	*Type of surface with which some noise barriers are equipped on the source side with the intention of reducing sound reflections*
Absorptive road or ground surfaces	*Surface for which a substantial part of the incident acoustical energy is absorbed e.g. loose gravel, sand, some porous pavements and ground covered by grass, ivy, or other low-growing vegetation*
High speed (normally associated with motorway traffic in rural or suburban areas)	*Traffic operating at a speed of 100km/h and more*
Low speed (normally associated with urban traffic)	*Traffic operating at a speed of 45 to 64km/h*
Maximum sound level	*Highest sound pressure level recorded by the measuring device during a vehicle pass-by, using the appropriate frequency weighting and time weighting F, for vehicles which are acoustically identifiable, i.e. are not significantly disturbed by other vehicles*
Medium speed (normally associated with suburban areas or on rural highways)	*Traffic operating at a speed of 65 to 99km/h*
Power unit noise	*Noise generated by the vehicle engine, exhaust system, air intake, fans, transmission*
Reference surface	*Surface selected according to the purpose of the measurement, following certain rules listed in BS EN ISO 11819; levels on the reference surface are normalised to zero level (0dB) and levels on all other surfaces are presented as differences from this reference level*
Statistical Pass-By (SPB) method	*Measurement procedure designed to evaluate vehicle and traffic noise generated on different sections of road surface under specific traffic conditions*

Statistical Pass-by Index (SPBI)	*Noise index for comparison of road surfaces, that is based on the Vehicle Sound Levels and takes into account the mix and speeds of vehicles*
Traffic noise	*Overall noise emitted by the traffic running on the surface under study*
Tyre/road noise	*Noise generated by the tyre/road interaction*
Vehicle categories	*A vehicle category consists of vehicles which have certain common features easy to identify in the traffic stream, such as the number of axles or the size. The common features are assumed to correspond to similarities in their sound emission when driven under the same operating conditions.*
Vehicle category No. 1 – cars	*Passenger cars excluding other light vehicles*
Vehicle category No. 2 – heavy vehicles	*All trucks, buses and coaches with at least two axles and more than 4 wheels*
Vehicle category No. 2a – dual axle heavy vehicles	*Trucks, buses and coaches with 2 axles and more than 4 wheels*
Vehicle category No. 2b – multi-axle heavy vehicles	*Trucks, buses and coaches with more than 2 axles*
Vehicle noise	*Total noise from an individual vehicle, the major components of which are power unit noise and tyre/road noise*
Vehicle sound level L_{veh}	*Maximum A-weighted sound pressure level determined at a reference speed from a regression line of the maximum A-weighted sound pressure level versus the logarithm of speed, calculated for each vehicle category*

Table 1 Perceived relative comparison of surface dressing with other surfacing options

Key factor	Condition	SD*	HRA	PA	Thin	SMA
Cost/ sustainability	Total cost	5	2	1	3	2
	Aggregate	5	4	2	2	2
	Bitumen	5	1	2	2	2
	Equipment	4	2	3	3	3
	Workforce	3	2	4	4	5
Environmental conditions during construction	Rain	1	2	2	2	2
	Cold temperatures	2	4	4	4	4
	Hot temperatures	3	4	4	4	4
	Humidity	3	5	5	5	5
Performance characteristics	Grip (initial)	5	3	3	3	3
	Texture (initial)	5	3	4	4	4
	Structural	0	3	2	1	4
	Rutting	N/A	2	3	4	5
	Cracking	3	4	4	3	5
	Ride	0	4	4	4	5
	Spray	3	1	5	3	4
	Durability	2	5	3	3	5
Requirement for ancillary works		5	1	1	3	2
Energy use		5	1	2	3	2
Recycling/reuse possibilities		4	4	4	4	4
Disruption to road user during construction		5	1	2	3	2
Disruption to road user during replacement with same		5	1	1	3	1
Ranked noise dB(A)		0	1	5	4	3

Note: The ranking assumes the following:

5 most beneficial, 1 least beneficial, 0 not relevant
PSV 60 aggregate and polymer modified binder
Cost weightings based on cost per m^2 as laid, excluding preliminaries
Equipment ranking assumes seasonal utilisation for surface dressing
Humidity ranking based on use of emulsion bitumen
Surface codes:
SD – surface dressing -14/6 “racked in”
HRA – 30/14 hot rolled asphalt
PA – 14mm Porous Asphalt
Thin – typical proprietary thin surfacing, also to include micro-asphalt
SMA – typical 14mm stone mastic asphalt

Table 2 Test surface details

Type of surface (abbrev.)	Location	Age	Rock type	Texture depth (Sand patch)	Other details
20mm HRA (HRA)	Coventry	2 years	PSV >60 gritstone	2.00mm	Sampled from lay-by adjacent to busy dual carriageway
14/6mm surface dressing (14/6SD)	Lough-mourne Road	1 week	PSV >60 gritstone	3.24mm	Rural lightly trafficked
10/6mm surface dressing (10/6SD)	Colling-wood	1 year	PSV >60 gritstone	0.97mm	Within 30mph limit, leaving town
10mm surface dressing (10SD)	Cairn Road	1 week	PSV >60 gritstone	2.33mm	Rural lightly trafficked
6mm surface dressing (6SD)	Coalville	2 years	Blend of 2 PSV >60 aggregates – gritstone + igneous	1.12mm	Heavily trafficked bypass
14mm SMA (14SMA)	Moira	2 years	PSV >60 gritstone	1.50mm	Heavily trafficked roundabout
10mm close graded wc macadam (10bitmac)	Lough Road	1 week	PSV >60 gritstone	1.03mm	Lightly trafficked rural
Smooth resin	NA	NA	NA	0mm (with transverse joints)	Resin poured into empty moulds to create a smooth running surface with transverse joints at 240mm spacings
Smooth steel	NA	NA	NA	0mm	Internal running surface of ULTRA giving a continuous smooth surface with no joints

NB – 10SD or 6SD indicates a single dressing & 10/6SD or 14/6SD a racked – in dressing.

Table 3 Summary of data for smooth tyre, test speed 50 and 100kph, load of 40kg and tyre pressure 20psi

Surface	Leq at 50kph	Leq at 100kph	Increase from 50 to 100kph	USI at 50kph	USI at 100kph
10bitmac	91.7	101.3	9.6	-5.1	-6.3
14SMA	95.2	105.5	10.3	-1.6	-2.1
14/6SD	97.6	106.9	9.3	0.8	-0.7
10SD	95.0	104.4	9.4	-1.8	-3.2
10/6SD	93.2	104.7	11.5	-3.6	-2.9
6SD	93.0	102.6	9.6	-3.8	-5.0
Smooth resin	89.4	101.2	11.8	-7.4	-6.4
Steel rim	83.4	96.3	12.9	-13.4	-11.3
HRA	96.8	107.6	10.8	0	0

Table 4 Summary of data for treaded tyre, test speed 50 and 100kph, load of 40kg and tyre pressure 20psi

Surface	Leq at 50kph	Leq at 100kph	Increase from 50 to 100kph	USI at 50kph	USI at 100kph
10bitmac	96.3	106.6	10.3	0.3	0.2
14SMA	94.3	104.7	10.4	-1.7	-1.7
14/6SD	97	107.9	10.9	1	1.5
10SD	95.6	104.9	9.3	-0.4	-1.5
10/6SD	95.1	105.9	10.8	-0.9	-0.5
6SD	94.3	104.9	10.6	-1.7	-1.5
Smooth resin	97.1	109.2	12.1	1.1	2.8
HRA	96	106.4	10.4	0	0

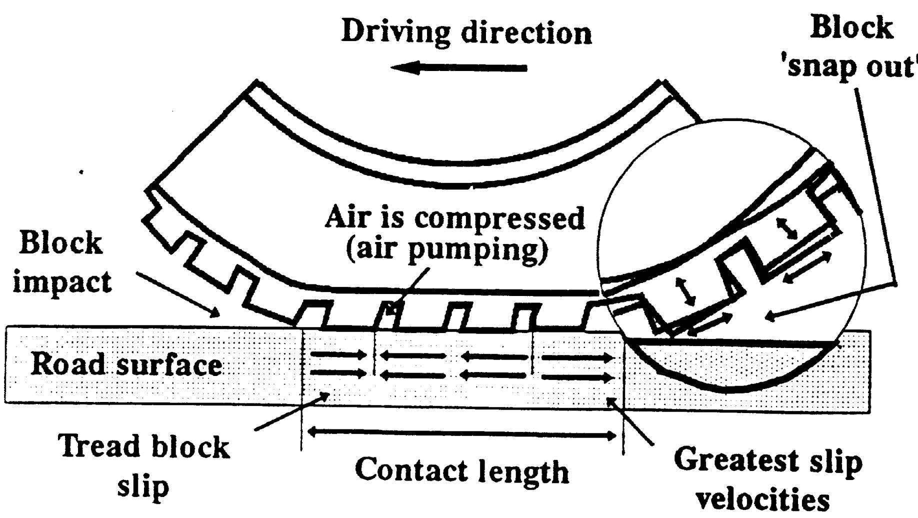


Figure 1 Main mechanisms involved in the generation of tyre/road noise

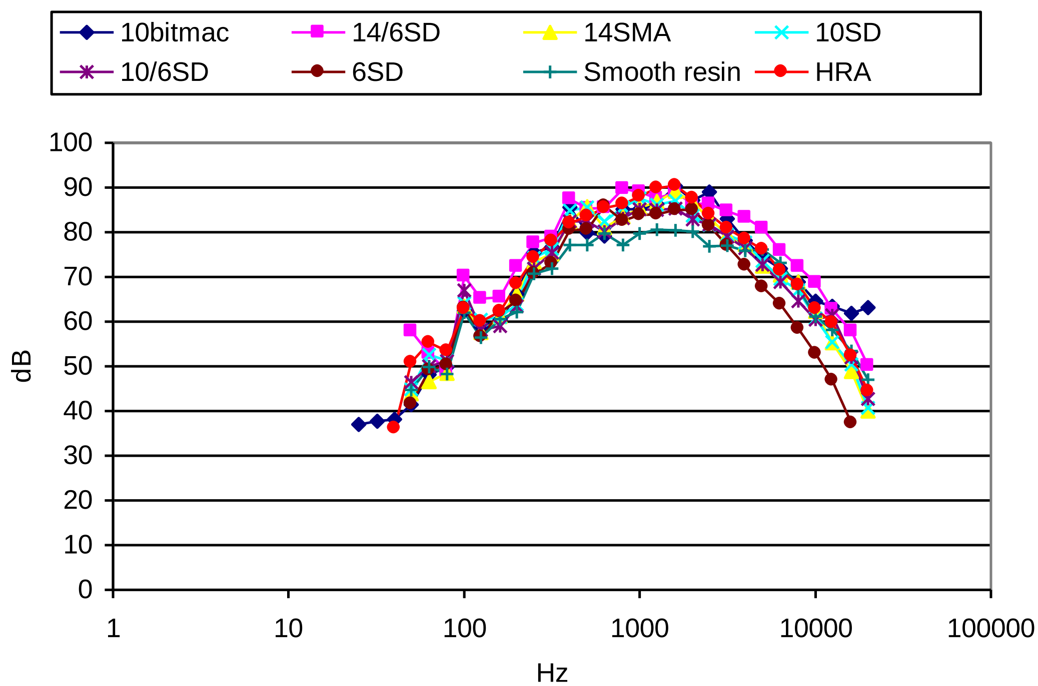
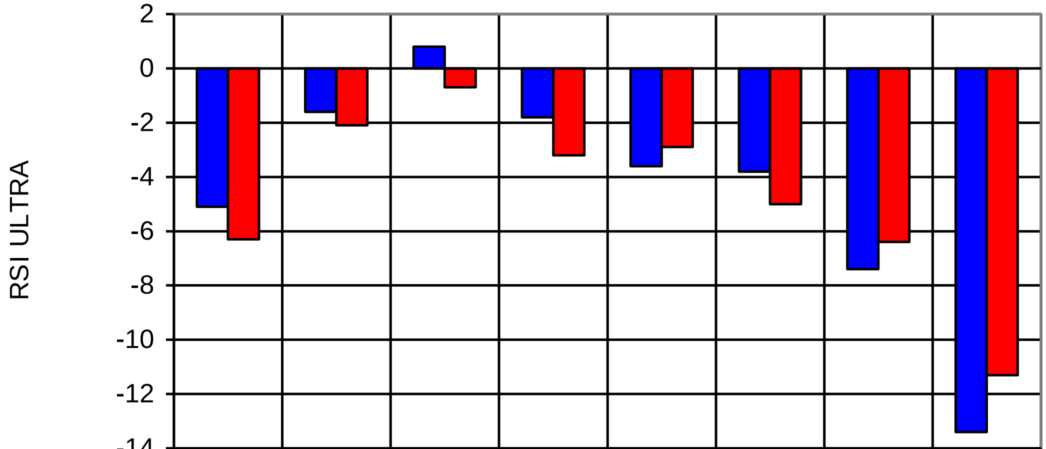
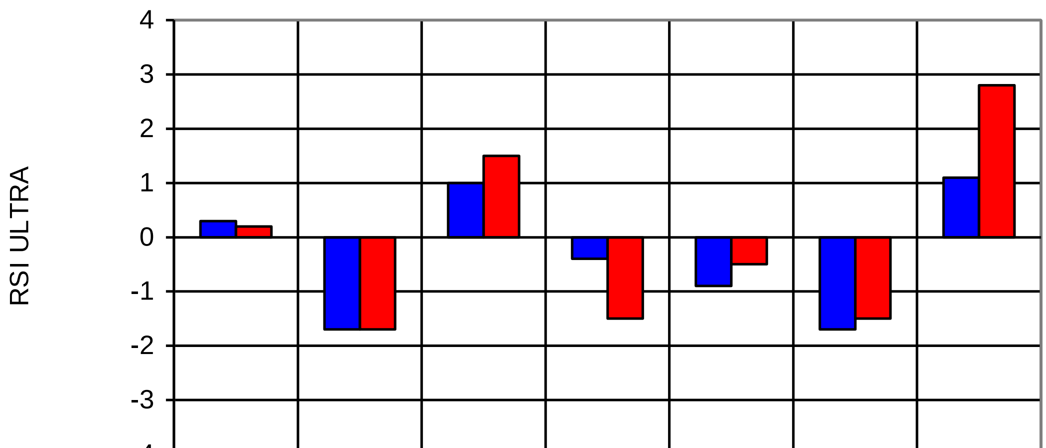


Figure 2 Plot of noise data for different test surfaces (smooth tyre, 40kg load, 50kph, 20psi)



	10 bitmac	14SMA	14/6SD	10SD	10/6SD	6SD	Smooth resin	Steel rim
50kph	-5.1	-1.6	0.8	-1.8	-3.6	-3.8	-7.4	-13.4
100kph	-6.3	-2.1	-0.7	-3.2	-2.9	-5	-6.4	-11.3

Figure 3 **Summary of USI noise test data (smooth tyre, test speed 50 and 100kph, load of 40kg and tyre pressure 20psi)**



	10bitmac	14SMA	14/6SD	10SD	10/6SD	6SD	Smooth resin
50kph	0.3	-1.7	1	-0.4	-0.9	-1.7	1.1
100kph	0.2	-1.7	1.5	-1.5	-0.5	-1.5	2.8

Figure 4 **Summary of USI noise test data (treaded tyre, test speed 50 and 100kph, load of 40kg and tyre pressure 20psi)**

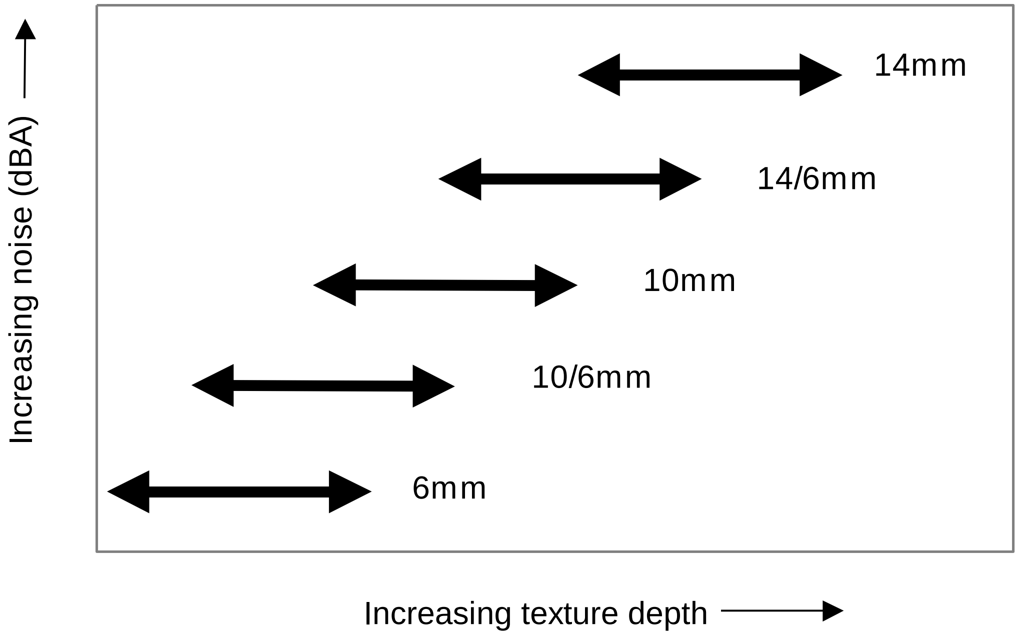


Figure 5 General relationship between noise and texture depth for different surface dressings

APPENDIX A

FEEDBACK ON THIS DOCUMENT

Any observations, feedback or complaints ***relating to the content of this document*** **or the process described** herein should be addressed (using the form below) to:

Chief Executive

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Glaisher Drive, Wolverhampton WV10 9RU

Email: enquiries@rsta-uk.org

Tel: 01902 824325

Issue Identified:

Suggested Action:

Name:

Organization:

Address:

Contact details:

Date:

APPENDIX B

DOCUMENT CONTROL

Issue Statement

Issue 5	2008
Issue 6	2011
Issue 7	2014

REVISION LIST – AMENDMENTS MADE IN THIS ISSUE

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